

DARPA “TRUST in IC’s” Effort

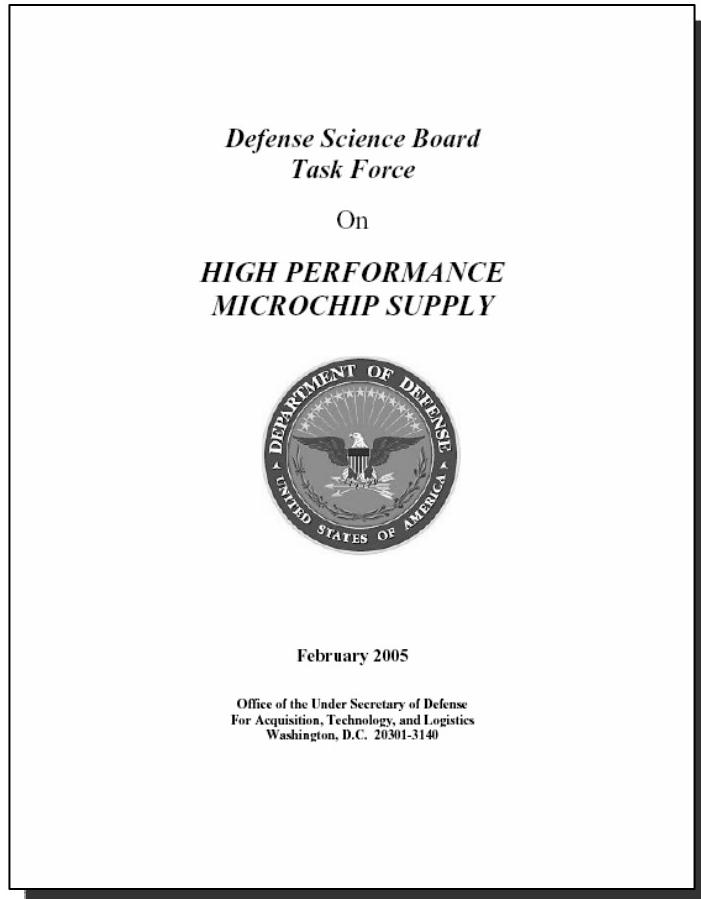


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7 March 2007**

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High Performance Microchip Supply



http://www.acq.osd.mil/dsb/reports/2005-02-HPMS_Report_Final.pdf

- For the DOD's strategy of information superiority to remain viable, the Department requires:
 - Trusted, Affordable, Timely Supply of Integrated Circuits (ICs)
 - A continued stream of exponential improvements in the processing capacity of microchips and new approaches to extracting military value from information.
- Technical Aspects of Trusted Circuits:
 - Design
 - IC Fabrication
 - IC Packaging



Technical and Structural Vulnerabilities



- A small number of special circuit IC components are essential for the nation's defense. Many have no commercial demand:
 - Radiation hardening, high power microwave, mm-wave and sensors.
- Global economic pressures are driving IC design and manufacturing to foreign soil and out of US control to ensure trust and availability:
 - Taiwan, PRC, Singapore, Korea and Japan
 - Cost for building 300mm wafer, 65nm chip fabrication plant is now approaching \$3B.
 - In addition to trust, the country faces a potential “Reverse-ITAR” restriction environment for future supply
- Dedicated facilities (NSA, Sandia, Honeywell, etc.) cannot provide the performance, variety and volume of DOD needs.
- This creates significant future vulnerability for critical systems:
 - Trust cannot be added to circuits after fabrication
 - Reverse engineering cannot be relied upon to detect undesired IC alterations.
- “Trusted Foundry Program” provide interim measure for trusted high performance IC’s – “take or pay” basis



What is the Nature of the Adversary?



- **It is assumed that the adversary is a nation/state with modern semiconductor capability that has the:**
 - Motivation
 - Opportunity
 - Talent
 - Manpower
 - Time / Patience

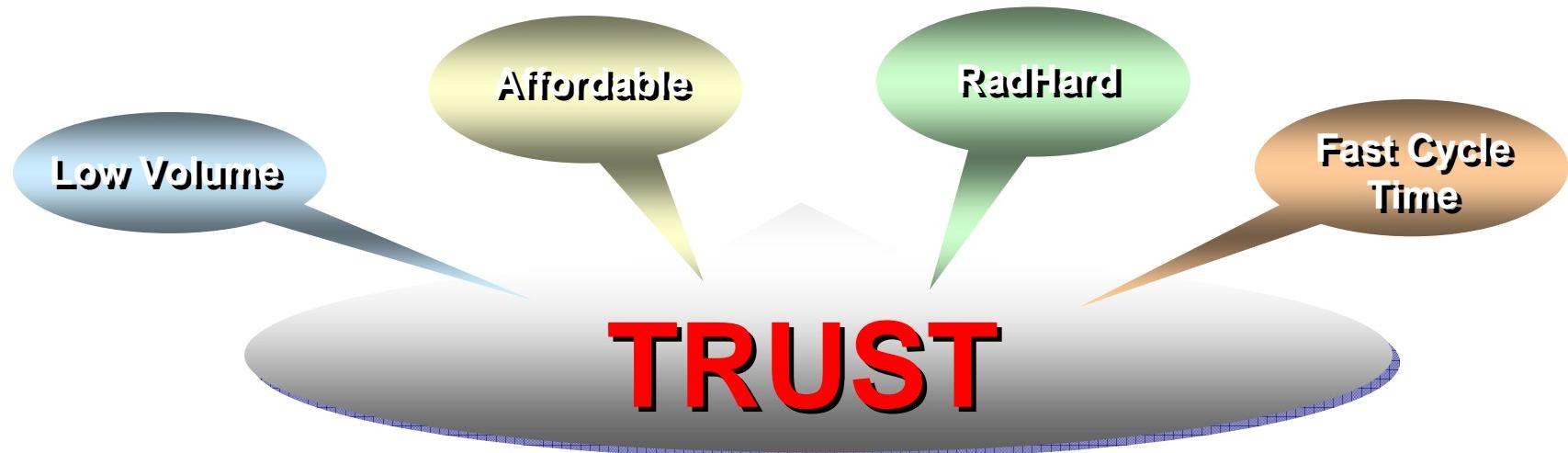
to do significant harm to the USA



“Overlap of TRUST with Other Issues”



- Although TRUST is not synonymous with RadHard, affordable, low volume and fast cycle time, many customers for trusted parts also desire these other attributes



Trustworthy computing (with software) cannot exist until we have trustworthy hardware to build it on



TRUST Commercial Efforts



Automobiles (GM)

Smart Cards/Smart Keys (Samsung, Infineon)

Integrated Circuits – (INTEL)

Cell Phones – (Motorola)

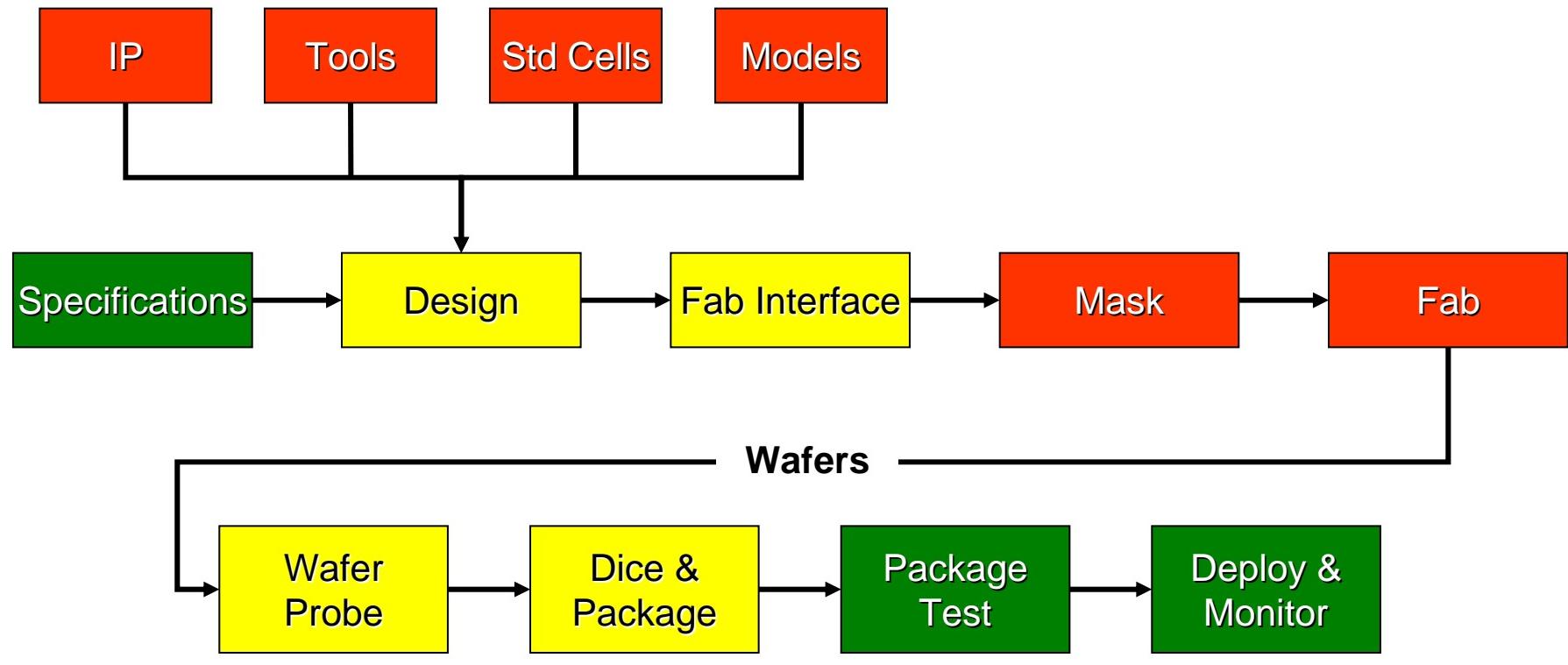
Set Top Boxes – (Motorola)

Secure Blue – (IBM)

**Commercial Reverse Engineering – (Chipworks,
Semiconductor Insights, CPU Tech)**

The government can benefit from commercial practices

New Supply Chain Structure





DARPA Hard Problems



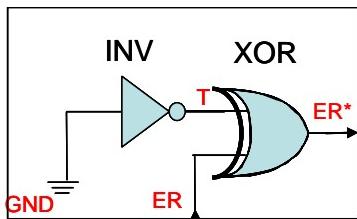
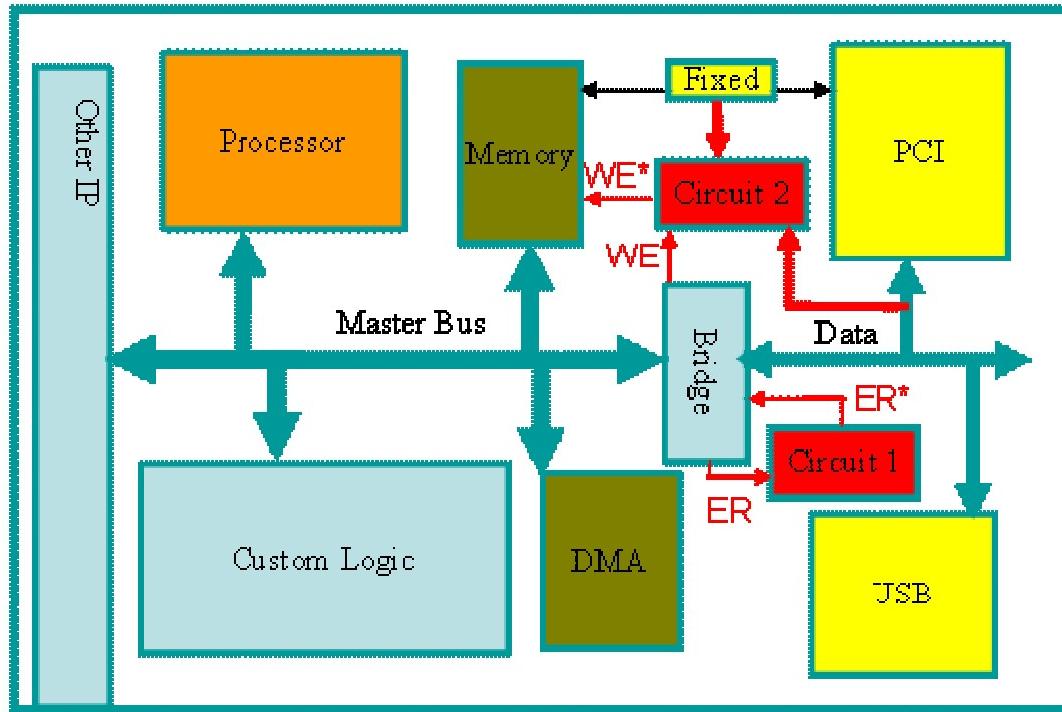
- How do you trust the design cycle to faithfully generate only the microelectronics desired?
- How do you trust microelectronics chips when they are manufactured in a non-trusted facility, such that they will faithfully perform only the function they are designed for?
- How do you trust that the testing on the microelectronic chips will faithfully determine that the chip will operate only as designed. (no more – no less)
- How do you know that the packaging of the chip does not introduce features into or misidentify the chip?
- How do you determine that the packaged chip has not been tampered with after installation, and how do you communicate the fact of tampering?



Areas of Interest

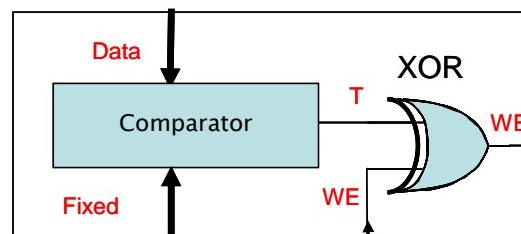


- **CASE1:** Given an IC corresponding to a known design, does the IC that is delivered do what it is supposed to do and nothing more? This is the case when the Fabrication facility is not trusted but the design process is. The problem is to determine whether the IC hardware received has been modified in order to determine that the fabrication can be trusted.
- **CASE2:** Given a specification and an IC design is the design true to the specification? In this case one assessing the trust of the design software and synthesis tools. The design itself must be validated.
- **CASE3:** Given a re-configurable IC, does the configurable data (bit stream) in the device accurately represent what was intended by the specification, design and VHDL synthesis?



| T | ER | ER* |
|---|----|-----|
| 1 | 0 | 1 |
| 1 | 1 | 0 |

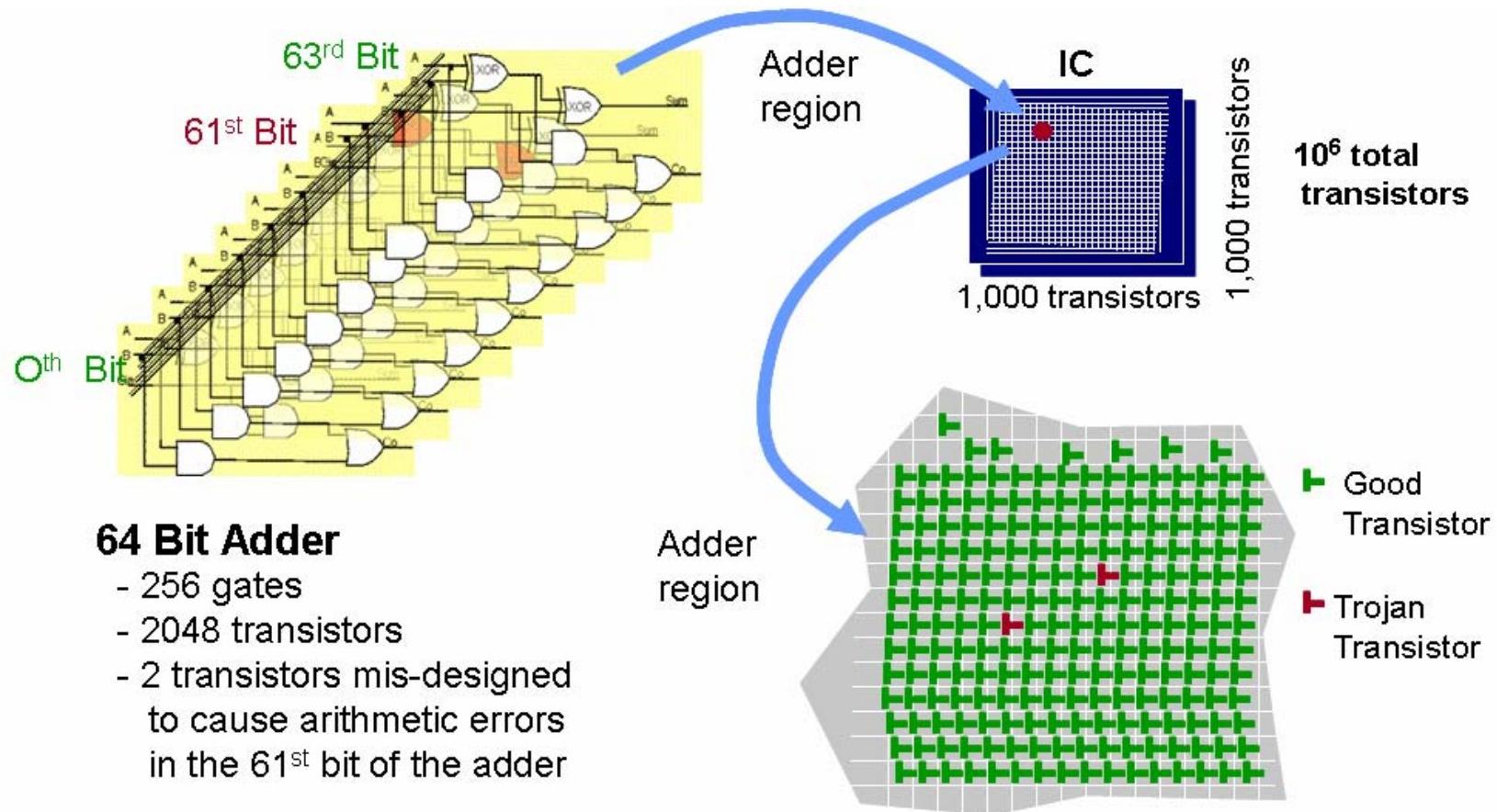
Example Circuit 1 – Trigger Always On



Example Circuit 2 – Event Triggered Condition

| Data | Fixed | T | WE | WE* |
|------|-------|---|----|-----|
| 232 | 234 | 0 | 0 | 0 |
| 233 | 234 | 0 | 1 | 1 |
| 234 | 234 | 1 | 0 | 1 |
| 235 | 234 | 0 | 0 | 0 |

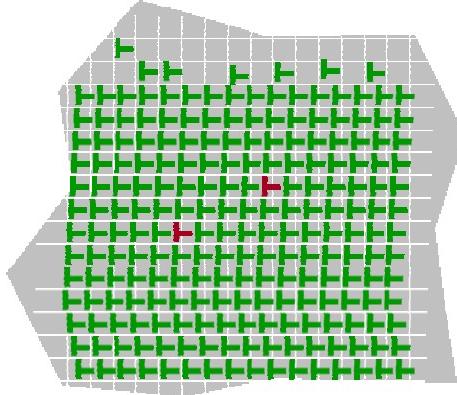
Metrics Challenge



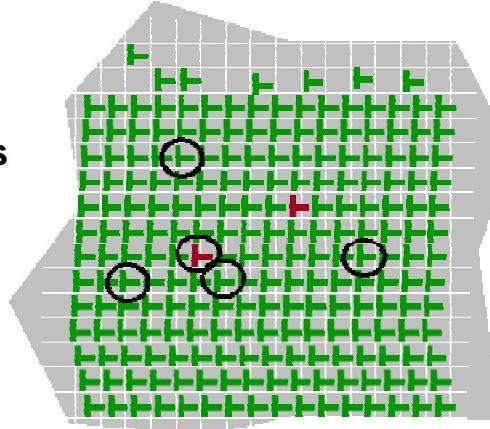
How Does One Quantify the Performance of Alternative Approaches to Detect Additions, Deletions, and Modifications to the Desired Design ?

P_D/P_{FA} Metrics Considerations

Example 1 – Tests Performed at the Transistor Level



Transistors
called
bad

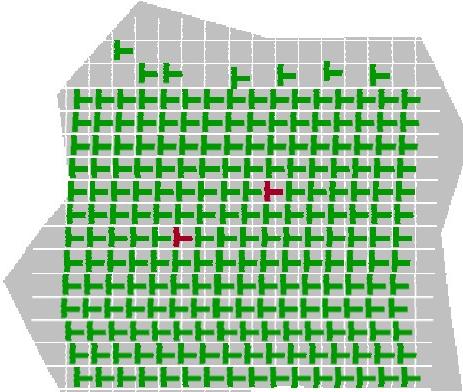


Test at Transistor Level – “rogue”
transistors detected

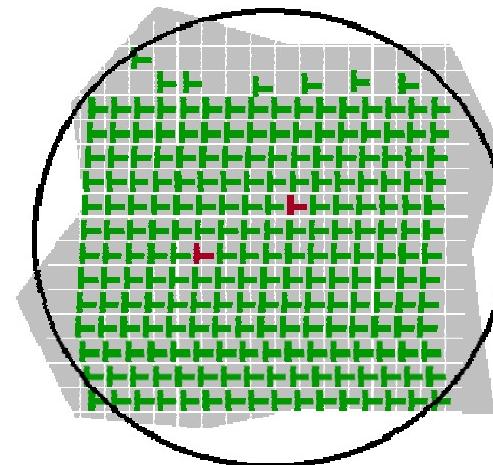
$$P_D = 1/2 = 50.0\%$$

$$P_{FA} = 4/10^6 = 4*10^{-6}$$

Example 2 – Tests Performed at the Functional Level



Adder
called
bad



Test at Functional Level - “2048
transistor adder does not function
properly”

$$P_D = 2/2 = 100.0\%$$

$$P_{FA} = (2048-2)/10^6 = 2.046*10^{-3}$$



Key Technical Challenges



Key technical challenges for TRUST in ICs include:

- Destructive reverse engineering of an IC in a cost and time efficient manor.
- Determining if all the chips on a single wafer are identical.
- Determining the effectiveness of a non-destructive reverse engineering techniques.
- Sensitivity and effectiveness of software techniques to prevent and/or detect the insertion of malicious circuits during the design cycle.
- Determining the independence of various transistor Pd measurements.
- Relating transistor level Pd/Pfa metrics to IC level Pd/Pfa metrics.



Further Interests



Other areas of personal interest beyond TRUST in ICs:

- Device technologies that extend beyond Moore's Law.
- Device technologies which allow effective circuit level learning to take place.
- Devices based on entangled quantum effects such as matter waves, quantum computing and quantum key distribution
- Circuit functions which adapt to the environment.
- Complex Microsystems which marry advanced architectures to unique devices.
- Recruiting high quality Program Managers for MTO